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December 19, 2001

Robert Pernell, Commissioner
Presiding Member, Energy Efficiency Committee
California Energy Commission
1516 Ninth Street, MS 33
Sacramento, CA 95814

In The Matter Of:)
REVIEW OF CONCERNS RAISED BY TYCO ADHESIVES)
ON BUILDING ENERGY EFFICIENCY STANDARDS)
REQUIREMENTS FOR CLOTH BACK RUBBER ADHESIVE DUCT TAPE)

Commissioner Pernell:

My name is Max Sherman. I am a Staff Senior Scientist, Ph.D. and Group Leader at the Lawrence Berkeley National Laboratory. I am and have been the Principal Investigator for work on residential thermal distribution systems at LBNL and specifically for the sealant longevity work of concern to Tyco adhesives and the Commission. I presented information at the June 14, 2001 workshop on these issues and I would like to take this opportunity to provide additional information to assist the Commission.

Much of the background and summary of our results is contained in the June 12, 2001 memo I sent to you in advance of the workshop; I will not repeat it here. At the workshop the tape industry discounted our results because of their concern that our tests were not done using common joints. We continue to stand by our earlier conclusions and the usefulness of our data. The purpose of this memo is to indicate which results apply to common joints and how.

The focus of this memo is on the performance of cloth-backed, rubber adhesive duct tapes, commonly known as ***duct tape.*** Our field and laboratory results have shown that the other sealant products one might use perform much better, so I will not discuss them. Furthermore, as UL 181B-FX is required for all duct tapes, I will limit my discussion to products meeting that standard.

Background

There are many kinds of thermal distribution systems possible, but by far the most common type in new California construction uses flexduct. Flexduct is made up of an inner membrane called the ***core***, a layer of insulation and an outer membrane called the ***jacket***. In a flexduct system, there are two basic configuration of the joints: the round-to-round joint and the round-to-flat joint.

The round-to-round joint is typical when a piece of the flexduct terminates so it can be joined to something else, usually via a metal collar. In a round-to-round joint the tape joins two concentric materials, which can be done with a single piece of tape kept flat as it goes around the joint. The industry focuses on the ***core-to-collar*** joint, but there can also be ***jacket-to-collar*** joints, ***jacket-to-jacket*** and ***collar-to-collar*** joints. Failure of seals to the jacket usually does not result in excessive air leakage, but can lead to degradation and early failure of flexduct.

The round-to-flat joint is typical when a metal collar attaches to branch, splitter or plenum. All of these joints are quite similar in behavior. As the most common one is the ***collar-to-plenum*** joint, we shall use that term. In collar-to-plenum joint the tape must be used to seal over a right-angle bend and it normally requires many pieces of tape.

The collar-to-plenum joint is normally a metal-to-metal joint in which the round collar is mated through a circular hole to a flat piece of metal. There are a series of overlapping finger joints that leave gaps of 1/8" to _" that must be sealed. There are approximately as many collar-to-plenum joints as core-to-collar joints, but because of the larger size of the underlying holes, they can have a larger impact on air leakage.

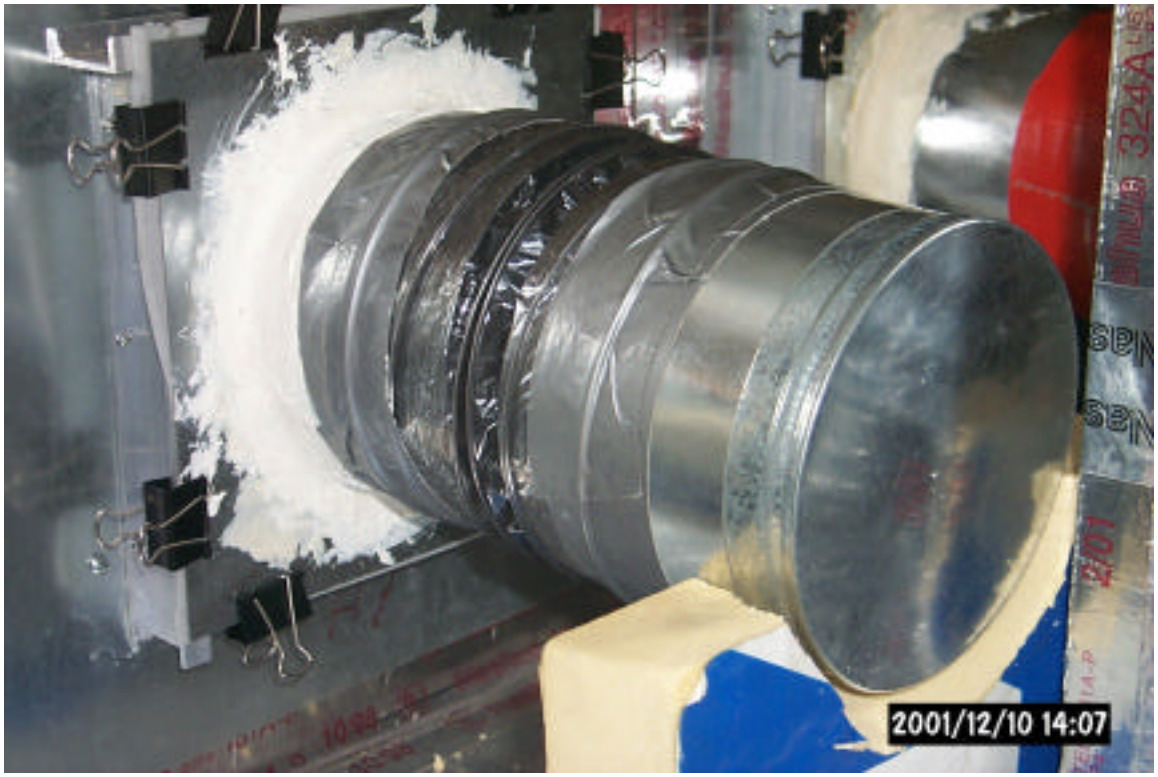

Figure 1. Laboratory examples of flexduct joints

Figure 1 is a laboratory construction, which contains two core-to-collar joints and one collar-to-plenum joint. In the center of the round section there is a flexduct core attached on either side to collars with duct tape. The white irregular

ring of material at the back (left) is mastic which has been applied over the collar-to-plenum joint. The end of the duct is capped off.

Joint Quality

There are three qualities of joints that the Commission may need to consider: "code minimum," "typically installed," and "industry recommended." For each type of joint these three qualities can be different. Although "code minimum" should be expected and "industry recommended" would be desirable, it is often found that "typically installed" actual practice does not meet either "code minimum" or "industry recommended," so it is important to consider what each of these three conditions will mean to the quality of the joint.

State code requires that all joints be mechanically secured and air sealed. The code also requires that flex duct sealants meet UL 181B. It should be noted, however, that UL 181B states that it only applies to the jacket and to core-to-collar joint, but not to the collar-to-plenum joint. UL 181B requires that the core-to-collar joint have a mechanical clamp over the duct tape; this clamp is not required for the jacket.

Industry standards are probably best represented by those of the Air Diffusion Council[1] (ADC), the industry organization to "promote and further the interests of manufacturers of air distribution equipment…" These recommendations have details for duct-to-collar joints (e.g. use of 2 wraps of duct tape and references to UL 181B), but do not have recommendations for collar-to-plenum joints.

Typical installations vary widely in practice. Many installations are quite good; some are quite bad. Some installations do not meet code; some meet the

[1] ***Flexible Duct Performance and Installation Standards*** 1996; Air Diffusion Council, Chicago ll. Note that the industry uses the term "core-to-fitting" joint for what we call the "core-to-collar" joint.

code; but do not fully conform to manufacturers' and industry recommendations. Some of the problems seen in field installations[2] include the following:

- Duct and sheet metal materials are often not cleaned. Duct tape does not adhere well to dirty or oily surfaces.
- The code requires 2 wraps of tape around the joint, and imply that these should be continuous wraps. Field installations are often broken up into shorter segments because of access limitations and may not constitute 2 wraps.
- To meet code and UL 181B tie bands must be installed over the tape, over the duct. Tie bands are not always used in the field and when they are they may not be in this configuration.

LBL RESULTS: Collar-to-Plenum Joint

Our previous laboratory tests are directly relevant to collar-to-plenum joints, because that was the joint we tested in our longevity apparatus. Nothing in code prohibits the use of duct tape on this joint and field experience has shown that duct tape is often used applied on this joint even though manufacturers state that they do not recommend its use on this joint.

Figure 2 shows an example of a failed (UL 181B-FX) duct tape joint. The tested collar-to-plenum joint is covered by gray, curled tape, which has shrunk and pulled away from the metal. This example is typical. All duct tape samples failed whether they were UL 181 B-FX rated or not. No other products failed.

[2] In some cases standard practice can be better than industry recommendations. For example, the ADC recommends that tape be used on the outer membrane as a clamp (i.e. in a tight wrap around duct, not at the end). Standard practice is to tape the end of the membrane to the metal collar. Standard practice provides better air tightness and moisture resistance

Figure 2: Example of failed collar-to-plenum joint sealed with duct tape

Our collar-to-plenum samples represent common joints. Sheet-metal screws mechanically supported each sample. Combined with the duct tape, this satisfies code requirements for this joint. The ADC recommendations are silent on this joint, but duct tape manufacturers have stated that duct tape is not recommended for this joint.

One issue we have not tested is the impact of dirty surfaces on the sealability. It is not clear how one would define the dirty surface in a reproducible and agreed upon manner. We can assume that products would do worse on dirty surfaces than on clean ones. It is quite likely that some failures are due to dirty surfaces and that some sealants are more sensitive than others to this effect, but we are aware of no research on this topic.

LBL RESULTS: Round-to-Round Joint

Although our published results use a collar-to-plenum joint, we believe our results are transferable to other joints in the system. One of the key contentions of the tape manufacturers is that the tapes would perform better in the round-to-round configuration of a duct-to-collar joint than in the bent configuration of a collar-to-plenum joint.

After the June workshop we adapted our apparatus to try to address this issue. Since that time we have been able to test joints in a round-to-round configuration, specifically we have been testing a collar-to-collar joint. While this is only one of the round-to-round configurations[3], we expect it to be representative as the stresses on the tape are similar for all of them. Our test joint has multiple wraps (more than the industry recommendation of two wraps) using a single piece of duct tape.

[3] Currently we are working with the Commission to conduct tests on the core-to-collar joints shown in figure 1, but results are not likely on this joint before summer 2002.

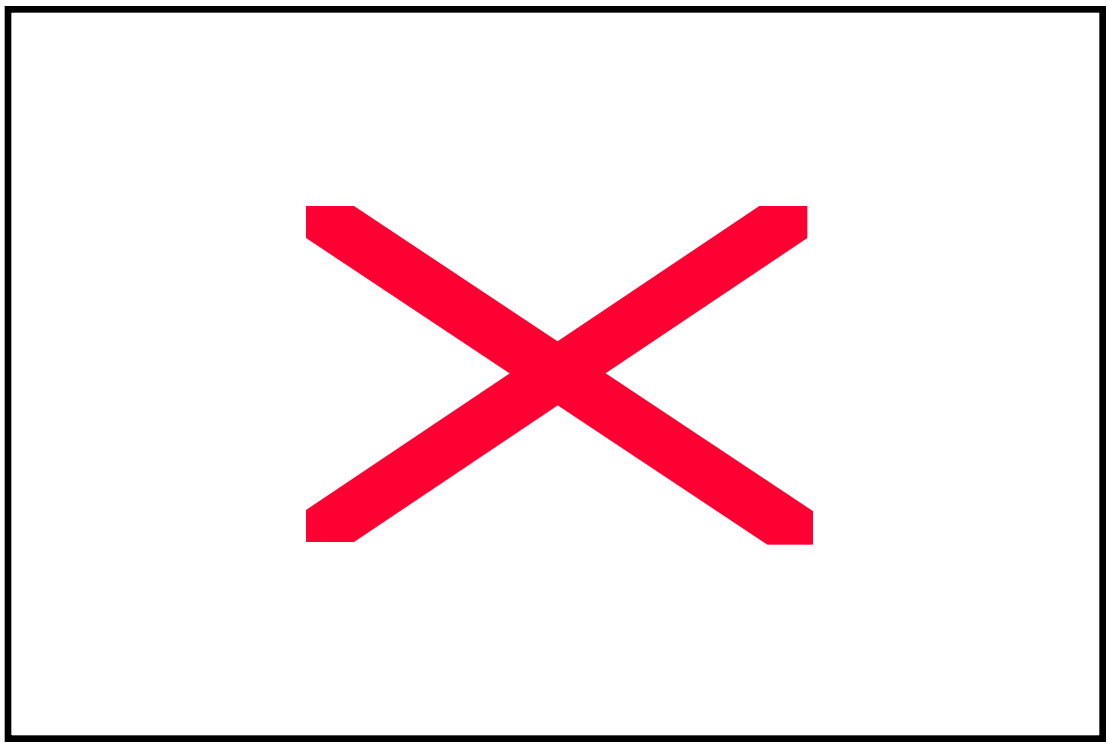

Figure 3: Duct tape tested in round joint configuration. The tested joint is in the center sealed with duct tape.

Figure 3 is a picture of one of the round-to-round samples tested for approximately 60 days under heat and pressure. While the deterioration is not as pronounced as in the collar-to-plenum tests, clear evidence of shrinkage and curling can be seen. The trailing edge of the tape is already beginning to pull away from the wrap below it. We have three other test samples of UL 181B-FX duct tape and all show similar features.

Because the underlying leakage of the test sample is relatively low, leakage is a trailing indicator of tape failure. Leakage tests have shown some increased leakage, but the catastrophic failures of the collar-to-plenum tests. Visual inspection is much better as a leading indicator of tape failure and we believe it should be the primary indicator in this kind of test.

Conclusions and Recommendations

- The use of cloth-backed, rubber adhesive tapes on typical duct systems in California will be likely cause the system to fail prematurely. Our tests support the Commission decision to separate these products out from the other duct sealant systems and give them special treatment.
- Duct tape used in a round-to-round joint will fail more slowly than if used in a collar-to-plenum joint, but will still be unacceptable. Other UL 181B products appear to work acceptably and should be allowed.
- For future standards the Commission should adopt a longevity performance criterion rather than a prescriptive criterion to allow the sealant industry to develop innovative products. A test similar to the proposed ASTM standard could be used to determine such ratings either as an independent test or as part of an industry standard such as UL 181B.

Thank you for giving us the opportunity to provide you with information. We would be happy to respond to any questions you may have.

Sincerely,

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